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Full length article

Development and evaluation of a machine for peeling and cleaning peanut seeds

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ABSTRACT

This study aims to develop and evaluate of machine peeling and cleaning peanut seed to be using in small and medium production units. All peeling and cleaning experiments of peanut seed were carried out at average moisture contents of 7.53% (d.b.) for seed. Experiments were conducted at drum speeds of 100, 200, 300 and 400 rpm, number of rows 4, 8 and 12 and air velocity 1, 2, 3 and 4 m/s. Results showed that the highest productivity was 80 kg/h with drum speed from 400 rpm and number of rows 4, while the highest value of peeling efficiency was 99.1 % with drum speed of 400 rpm and 12 row. Results are also showed that the lowest value of broken seeds was 2.55 % at drum speed of 100 rpm and number of rows of 4. Also, at air velocities 1, 2, 3 and 4 m/s; Results showed that the highest values of cleaning efficiency were 96.15, 97.85, 98.15 and 99.15% respectively, were obtained at drum speed of 100 rpm and 12 row. While lowest values of cleaning efficiency were 94.25, 96.55, 96.65 and 97.50% at air velocities 1, 2, 3 and 4 m/s respectively, were obtained at drum speed of 400 rpm and 4 rows.

1. Introduction

Peanut (*Arachis hypogaea* L.) is the six most important oilseed crop in the world. It contains 48-50% oil and 26-28% protein, and is a rich source of dietary fiber, minerals and vitamins. It grows best on soils that are well drained, loosely textured and well supplied with calcium, potassium and phosphorous. Over 100 countries worldwide grow groundnut, (Ntare et al., 2014). Peanut is generally recognized as one of the most important oil crops in the world because peanut oil is considered one of the best for cooking because of its high smoke point (Zafar et al., 1997).

Peanut seeds are important nutritional and economical crop, used for human feeding and different industrial asp`ects such as sweets, peanut butter, paint, insecticides, nitroglycerin etc. (Mady, 2017).

The total cultivated area of peanut in Egypt about 150348.2 Feddan and producing about 189745.15 Mg according to, (FAO, 2017).

Awady and El-Sayed (1994) reported that, the terminal velocity was found to be 4.3, 6.5, 6.8 and 7.2 m/s for shells, unshelled, split and intact seeds respectively. The separation air speed of 5.7 m/s was recommended for good separation of peanut seeds. Although hand shelling of peanut is a very low process and requires much time and labors but it gives minimum loses and seed damage.

Helmy et al. (2013) evaluated performance of a reciprocating peanut sheller before and after modification by supplying the sheller with feeding mechanism (conveyor belt), increasing the friction area of shelling box, and using rubber for enhancing shelling process. The results showed that, the performance of a reciprocating peanut sheller after modification is better than that

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before modification. The shelling efficiency and productivity after modification were 98.85 % and 155.98×10^{-3} Mg/h, reps., at feed rate of 160 kg/h, box speed of 1.4 m/s, moisture content about 17.12 % w.b. and air velocity of 8.37 m/s. But before modification, the shelling efficiency and productivity after modification were 95.32 % and 89.20×10^{-3} Mg/h, reps., at feed rate of 100 kg/h and the other studied operating conditions.

Mady, (2017) manufactured and evaluated a peanut sheller under the following operational conditions; drum rotary speeds of 150, 200, 250 and 300 rpm, feeding rates of 170, 210 and 250 kg/h and air speeds of 4.9, 6.8 and 8.8 m/s. The results showed that the highest shelling efficiency was 96.23 % at drum speed of 150 rpm and feeding rate of 170 kg/h. The highest productivity of machine was 250 kg/h at drum speed of 300 rpm and feeding rate of 250 kg/h, whereas the highest cleaning ratio was 98 % was at drum speed of 150 rpm and air speed of 8.8 m/s.

Mousa and Darwish (2021) evaluated performance of a developed shelling/cracking machine for shelling of peanut pods (PPs), the results showed that; the used machine achieved high efficiency in shelling of PPs. Under the tested speed range [100 to 400 rpm] and the tested clearance range [9 to 12 mm], the optimum operation conditions for shelling of PPs was 200 rpm for speed and 10 mm for clearance. Under the tested sample mass range [200 to 1000 g], the mean values of shelling efficiency were not significantly with average of 97.54 %. Also, the mean values of %-age of unshelled pods, broken seeds, split seeds, intact seeds and shell with dust were not significantly with average of 2.46, 4.95, 14.52, 52.20 and 25.63 %, resp. The results revealed that the highest value of machine productivity was 48.29 kg/h, whereas the mean value of power consumption was 689.59 W.

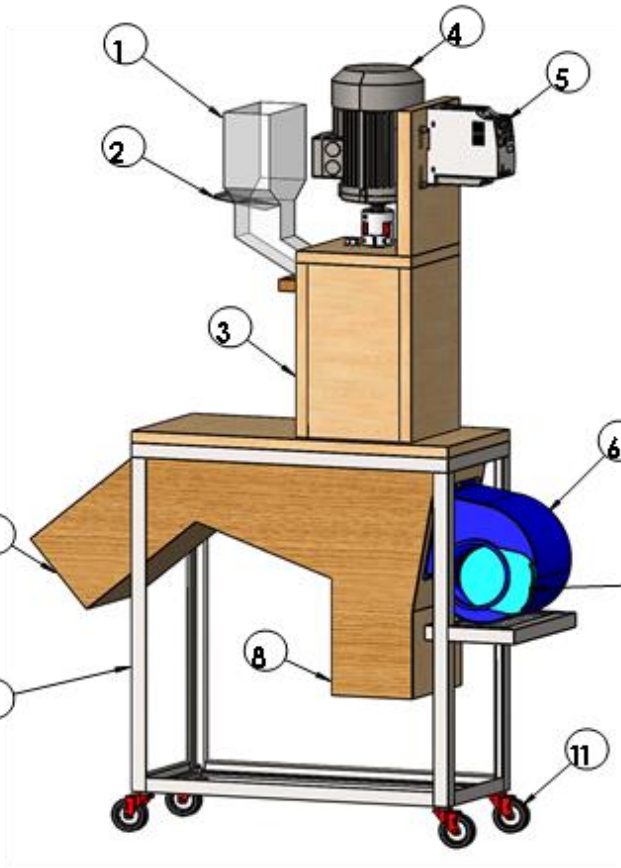
2. Materials and methods

2.1. Materials

Machine peeling and cleaning peanut seed is constructed, developed and tested in the Faculty of Agricultural Engineering workshop, the following items were considered in the peeling and cleaning machine design: processes safety, small scale and weight to have more mobility, using local materials to facilitate maintenance, easily refitted and dismantled.

2.1.1. Description the machine peeling and cleaning

The main components of machine of peeling and cleaning peanut seeds included: frame, feed hopper, peeling chamber, cleaning chamber, outlet of seeds, outlet of shell and source of power, as shown in Fig. 1.



(1) Feed hopper. (2) Hopper gate. (3) Peeling chamber. (4) Source of power. (5) Inverter. (6) Blower. (7) Blower gate. (8) Outlet of seeds. (9) Outlet of shell. (10) Mainframe. (11) Wheels.

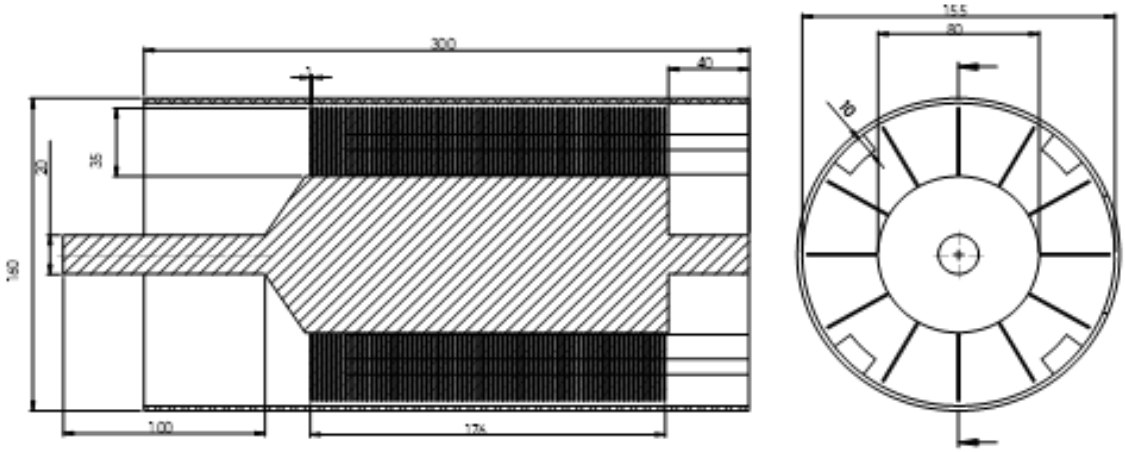
Fig. 1. Isometric of machine for peeling and cleaning peanut seeds.

2.1.1.1. Feed hopper

The feeding hopper was made of fiberglass sheet with 2 mm thick of conical shape, the top rectangle of 150×180 mm and bottom rectangle of 80×60 mm with 160 mm high.

2.1.1.2. Peeling chamber

The peeling chamber plays a substantial role in peeling peanut seeds from shell in our designed prototype. The peeling chamber is vertical cylinder of PVC, its dimensions of 155 mm for inner diameter, 300 mm height. Four fins of rubber having dimensions of 176 mm length, 30 mm width and 10 mm thickness are fixed on the inner surface of the peeling chamber parallel to the longitudinal axis, inside the cylinder is a rotating artalon drum fixed in the top of power source of the peeling chamber, twelve rows fixed on the longitudinal axis of the drum, under the peanut seed outlet opening, blower was fixed controlled of speed air to clean the seeds from shell and dust. The elevation and plan of peeling chamber are shown in Fig. 2.



Sec. Elevation **Plan**

Fig. 2. Elevation and plan of the drum peeling chamber. (Dims, mm)

2.1.1.3. Source of power

The electric motor of 0.33 hp was connected by inverter device to provide or reduce the rotary speed of the electric motor.

2.1.2. Measuring instruments

1) A digital electric balance: with accuracy of 0.01 g was used to weigh the mass of samples before and after peeling and cleaning. 2) A digital stopwatch: with accuracy of 1 s was used to record the peeling and cleaning time. 3) Electric oven: was used to determine the moisture content of seeds. 4) Digital photo tachometer was used to measure the rotational speed "rpm". The specs of tachometer are as follows: non-contact, but with laser photo, range of the measurement is 2.5 to 99999 rpm, and its accuracies are 0.1 rpm through the speed 2.5 to 999.9 and 1 rpm over 1000 rpm. 5) Anemometer: to measured air velocity inside the cleaning chamber (Range from 0 to 44 m/s, accuracy of 0.1m/s).

2.2. Methods

Experimental conditions: Experiments were carried out with drum speed 100, 200, 300 and 400 rpm, number of rows 4, 8 and 12 and air velocities 1, 2, 3 and 4 m/s.

2.2.1. Evaluation of the performance

2.2.1.1. Moisture content

The moisture content "M_c" of seed was determined using a hot air oven drying method at 105° C for 24 hours (**ASAE, 1994**). These tests were repeated five times. The moisture content was determined on dry basis by using the following:

$$M_C\ (\%) = \frac{M_b - M_a}{M_a} \times 100 \quad \text{... [1]}$$

where M_b: Mass of sample before drying, (g) and M_a: Mass of sample after drying, (g).

2.2.1.2. Productivity

Time of peeling was measured by means of a stopwatch to determine the machine productivity. The machine productivity " P_M "was calculated as follow:

$$P_M\ (kg/h) = \frac{M_t}{t} \quad \text{... [2]}$$

where M_t: Total mass of seeds, (kg) and t: Time consumed in peeling and cleaning process, (h).

2.2.1.3. Peeling efficiency

Peeling efficiency can be computed according to the following formula:

$$\eta_P\ (\%) = \frac{M_t - M_{unp}}{M_t} \times 100 \quad \text{... [3]}$$

where η_P: Peeling efficiency (%) and M_{unp}: Mass of un-peeling seeds, (kg).

2.2.1.4. Cleaning efficiency

Cleaning efficiency was calculated as follows:

$$\eta_C\ (\%) = \frac{M_{cl}}{M_t} \times 100 \quad \text{... [4]}$$

where η_C: Cleaning efficiency (%) and M_{cl}: Mass of clean sample, (kg).

3. Results and discussions

All experiments of peeling and cleaning for peanut seed (American variety) were carried out under the average moisture content of 7.53 % d.b.

3.1. Effect of the drum speed and number of rows on the machine productivity

Fig. 3 shows the relation between machine productivity, kg/h and drum speed (100, 200, 300 and 400 rpm) at different number of rows on the drum (4, 8 and 12 row). Generally, the machine productivity increasing with increase drum speed from 100 to 400 rpm but decreasing with increased number of rows. The highest value of productivity was 80 kg/h at drum speed from 400 rpm and number of rows 4. While the lowest value for productivity was 34.29 kg/h at drum speed from 100 rpm and 12 numbers of rows.

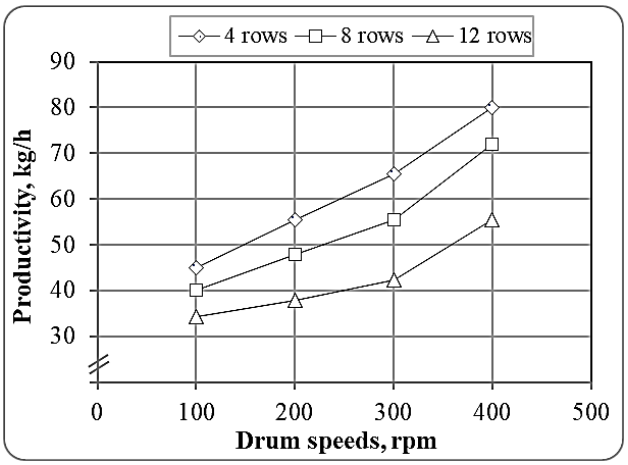


Fig. 3. The relationship between machine productivity "kg/h" and drum speed "rpm" at different number of rows on the drum.

3.2. Effect of the drum speed and number of rows on the peeling efficiency

Results in Fig. 4 revealed that, there is a positive relationship between the drum speed and number of rows on the peeling efficiency. Increasing drum rotational speeds from 100 to 400 rpm tends to increase the average of peeling efficiency from 95.8 to 99.1% at number of rows from 4 to 12 rows. The highest value of peeling efficiency was 99.1 % at drum speed of 400 rpm and 12 row. The lowest value of peeling efficiency was 95.8 % at drum speed of 100 rpm and 4 rows.

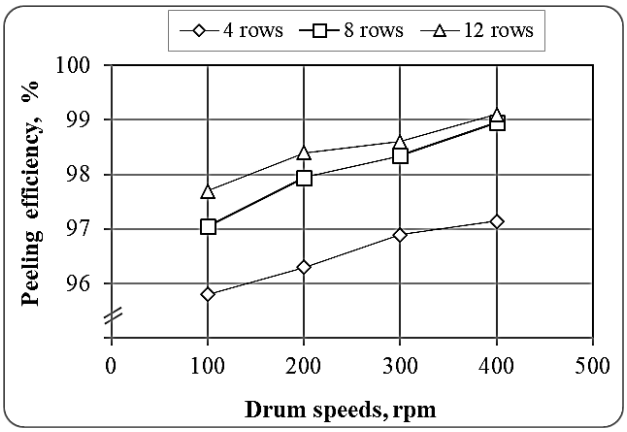


Fig. 4. The effect of drum speed "rpm" and number of rows on peeling efficiency "%".

3.3. Effect of the drum speed and number of rows on the broken seeds percentage

Fig. 5 showed that relation between broken seeds percentage and drum speed (100, 200, 300 and 400 rpm) at different number of rows on the drum (4, 8 and 12 rows). Results showed that the broken seeds percentage increases proportionally with increasing drum speed and number of rows. The lowest value of broken seeds percentage of 2.55 % at drum speed of 100 rpm and 4 rows. The highest value of broken seeds percentage of 8.75 % was obtained at drum speed of 400 rpm and 12 row.

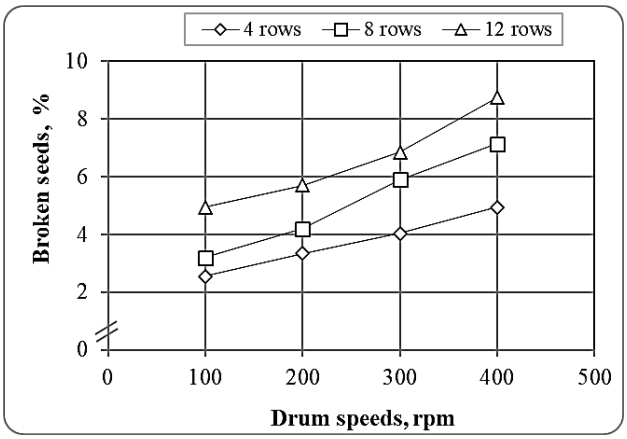


Fig. 5: The relationship between broken seeds "%" and drum speed "rpm" at different number of rows on the drum.

3.4. Effect of the drum speed, number of rows and air velocity on the cleaning efficiency

Data in Fig. 6 indicated that, there is an inverse relationship between the drum speed and number of rows on the cleaning efficiency. Generally, the cleaning

efficiency increasing with increase air velocity from 1 to 4 m/s and number of rows from 4 to 12 row but decreasing with increased drum speed from 100 to 400 rpm.

At air velocities 1, 2, 3 and 4 m/s; results showed that the highest values of cleaning efficiency were 96.15, 97.85, 98.15 and 99.15% respectively, were obtained at drum speed of 100 rpm and number of rows of 12. While the lowest values of cleaning efficiency were 94.25, 96.55, 96.65 and 97.50% at air velocities 1, 2, 3 and 4 m/s respectively, were obtained at drum speed of 400 rpm and 4 numbers of rows as shown Fig. 6.

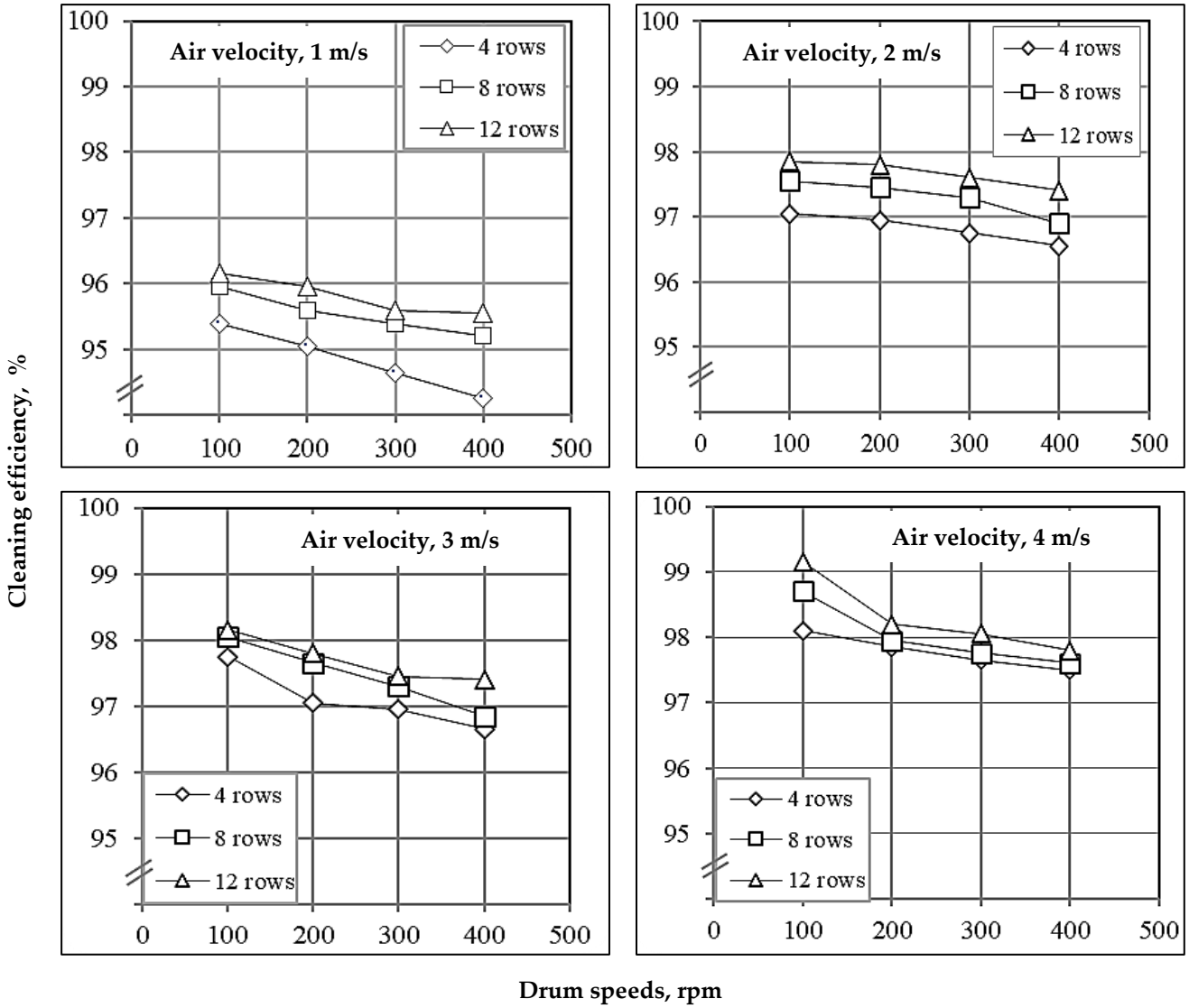


Fig. 6: show the effect drum speed "rpm", number of rows and air velocity "m/s" on the cleaning efficiency "%".

4. Conclusions

All peeling and cleaning experiments of peanut seed were carried out at average moisture contents of 7.53% (d.b.) for seed. Experiments were conducted at drum rotary speeds of 100, 200, 300 and 400 rpm, number of rows 4, 8 and 12 and air velocity 1, 2, 3 and 4 m/s.

The obtained results were summarized as follows:

- The highest value of productivity was 80 kg/h at drum speed from 400 rpm and number of rows 4. While the lowest value for productivity was 34.29 kg/h at drum speed from 100 rpm and 12 numbers of rows.
- The optimum operation conditions for peeling efficiency of 99.1% was 400 rpm for drum speed and 12 number of rows. While the lowest value of peeling efficiency of 95.8 % was obtained at drum speed of 100 rpm and 4 numbers of rows.
- The results revealed that the lowest value of broken seeds percentage of 2.55 % was obtained at drum speed of 100 rpm and number of rows of 4. The highest value of broken seeds percentage of 8.75 % was obtained at drum speed of 400 rpm and 12 numbers of rows.
- Under the tested air velocities 1, 2, 3 and 4 m/s; results showed that the highest values of cleaning efficiency

were 96.15, 97.85, 98.15 and 99.15% respectively, were obtained at drum speed of 100 rpm and number of rows of 12. While the lowest values of cleaning efficiency were 94.25, 96.55, 96.65 and 97.50% at the tested air velocities 1, 2, 3 and 4 m/s respectively, were obtained at drum speed of 400 rpm and 4 numbers of rows.

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تطوير وتقييم آلة لتقشير وتنظيف بذور الفول السوداني

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الملخص العربي

أجريت هذه الدراسة بهدف تصنيع وتقييم آلة بسيطة لتقشير وتنظيف بذور الفول السوداني تتناسب مع متطلبات الوحدات الإنتاجية الصغيرة والمتوسطة وتم تقييم أدائها لتناسب الغرض المصممة من أجله.

وتتمثل متغيرات الدراسة في الآتي:

١. سرعة درفيل التقشير ١٠٠ ، ٢٠٠ ، ٣٠٠ و ٤٠٠ لفه/دقيقة.

٢. عدد الصفوف على المحيط الخارجي للدرفيل ٤ ، ٨ و ١٢ صف.

٣. سرعة هواء التنظيف ١ ، ٢ ، ٣ و ٤ م/ث.

وكانت أهم النتائج المتحصل عليها كما يلي:

- الإنتاجية: سجلت الإنتاجية أعلى قيمة وهي ٨٠ كجم/ساعة عند السرعة الدورانية لدرفيل التقشير ٤٠٠لفه/دقيقة وعدد ٤ صفوف على محيط الدرفيل.
- كفاءة التقشير: كانت أعلى قيمة لكفاءة تقشير بذور الفول السوداني ٩٩,١٪ تم الحصول عليها عند سرعه دورانية لدرفيل التقشير ٤٠٠لفه/دقيقة وعدد ١٢ صف على محيط الدرفيل.
- البذور المكسورة: أقل نسبة بذور مكسورة كانت ٢,٥٥٪ سجلت عند سرعه دورانية لدرفيل التقشير ١٠٠ لفه/دقيقة وعدد ٤ صفوف على محيط الدرفيل.
- كفاءة التنظيف: تزداد كفاءة التنظيف بزيادة كلاً من سرعة هواء التنظيف وعدد الصفوف على محيط الدرفيل بينما تقل بزيادة السرعة الدورانية لدرفيل التقشير، حيث تم تسجيل أعلى قيمة لكفاءة التنظيف وهي ٩٩,١٥٪ عند سرعة هواء ٤ م/ث وعدد ١٢ صف على محيط الدرفيل وسرعه دورانية للدرفيل ١٠٠ لفه/دقيقة.